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(54) IMPROVEMENTS RELATING TO SELF-CLINCHING FASTENERS

(71) We, TEXTRON INC., of 10 Dorrance Street, Providence, Rhode Island 02903, United States of America, a Corporation of the State of Delaware, one of the United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to self-clinching fasteners and the method of assembly thereof. More particularly, the present invention concerns an improved form of fastener which will enable and ensure obtainment of a predicted, predetermined locking action with both thick and relatively thin sheet material.

Self-clinching fasteners are well-known in the art and are of numerous designs, employing various clinching or staking methods. Primarily, these prior art fasteners are of the type which are assembled in a pre-punched hole in a sheet material, and then the head portion thereof is seated and embedded in the upper surface of the sheet material to cause displacement of a portion of said material radially inwardly of the aperture causing said material to co-flow into an annular locking groove formed in the fastener. The mechanical interlock thus created provides the means for maintaining the fastener in engagement with the sheet material.

These prior art fasteners and methods of assembly are subject to certain disadvantages. First of all, as the aperture in the sheet material is prepunched, the dimensional tolerances which may be encountered will result in a wide variation in the relative sizes of the fastener and the aperture. As such, in some instances the fastener may fit snugly in the sheet material aperture prior to clinching, while in other instances an extremely loose fit will result. It can be appreciated that upon driving or embedding of the fastener head into the sheet material only a given amount of material will be displaced and moved radially inwardly. Therefore, where relatively loose fits are encountered, there is often insufficient material forced into the locking groove, resulting in a mechanical connection that is subject to failure in use. As will become apparent from the hereinafter description, the present invention will provide means whereby a mechanical connection of controlled, predicted strength is obtained, regardless of the thickness of the sheet material.

The degree or strength of the mechanical connection between the fastener and the sheet material is dependent upon the shear area achieved by the mechanical interlock. That is to say, for axial loading the shear area is defined as the cylindrical area at the groove radius of the material displaced into the locking groove. For a completely filled groove it will be the circumference times the axial width of the groove. Keeping in mind the above-discussed problem of tolerances, where incomplete filling of the locking groove results, the mechanical strength of the connection is not of the desired level. Also, it can be appreciated that it is desirable to make the width of the locking groove in the axial direction as great as possible in order to maximize the shear area. With thin materials, and prior art fasteners and methods of assembly, it was not possible to employ relatively wide grooves and thus the shear area of the mechanical interlock attained was inherently weak.

More specifically, with the prior art fastener designs employed with relatively thin material, the mechanical engagement between the fastener and the material was often insufficient to prevent backing out of the fastener during use. This was occasioned, due to the necessity of employing a groove having a width less than the sheet material thickness and the resulting, inherently low shear areas thus obtained.

With the self-clinching fastener of the

present invention, the sheet material aperture is reworked and sized to a desired, predicted configuration which not only assures close overlying engagement of the aperture walls with the fastener locking groove prior to clinching, but also can be utilized to increase greatly the amount of material available for displacement into the locking groove. This enables employment of a fastener with a relatively wide locking groove, and obtaining of the desired mechanical locking strength on both relatively thick and thin material.

The primary embodiment of the present invention achieves the above by employing an extruding nose portion on the fastener shank, which nose portion has a configuration generally convergent in the direction of entry through the sheet material. The extruding portion has an external dimension which is greater than that of the initial aperture formed in the sheet material. Accordingly, as the fastener is moved inwardly of the aperture, the sheet material adjacent the aperture will be engaged by the extruding portion and will be cold worked as said extruding portion passes through said aperture.

Two important results are achieved with the above-discussed structure and method of initial engagement. First, assuming use of relatively thick material, the difference in size between the initial aperture formed in the sheet material and the maximum dimension of the extruding portion will be slight, but sufficient to ensure a reworking or resizing of the aperture. Once the extruding portion has passed through the aperture, the aperture will be resized with the aperture walls being in close sliding contact with the fastener shank overlying the locking groove. Thus, upon embedding of the head portion in the upper surface of the sheet material, substantially all of the material displaced inwardly will flow into the locking groove, rather than being utilized to overcome dimensional tolerances. Further, the volume of material displaced can be predicted and the size of said head and the volume of the annular locking groove adjusted to achieve the predetermined desired mechanical interlock depending of course upon the intended use and forces to which the connector will be subjected.

Considering now use with relatively thin material an additional advantage is achieved over and above that discussed in the preceding paragraph. As mentioned previously, with thin material and the prior art methods the width of the locking groove was limited. With the present invention, the initial size of the aperture and the relative cross-sectional dimension of the extruding portion are selected such that a considerable amount of sheet material will be forced inwardly as the extruding section passes through the sheet metal aperture. This action will produce a rimmed hole with a relatively long aperture wall, the length of said aperture wall being greater than the initial thickness of the sheet material. There is thus produced a resized aperture of increased effective length with a considerable amount of material disposed about the aperture wall. In addition, as was discussed in the preceding paragraph, the aperture walls will be in close, overlying engagement with the fastener shank. Accordingly, upon embedding of the head of the fastener in the upper surface of the sheet material, not only will the major portion of the displaced material flow into the locking groove, but there is now afforded sufficient material to fill a relatively wide locking groove, a condition which could not be obtained without the resizing of the sheet material aperture.

In addition to the above, the present invention also contemplates the employment of locking protuberances on the head which each have an inclined undersurface, such that upon embedding of said protuberances in the sheet material, said inclined undersurface will assure radially inward movement of the displaced material, while precluding relative rotation.

For a better understanding of the invention some embodiments will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a partial sectional view showing a preferred embodiment of the present invention as employed with relatively thick material,

Figure 2 is a partial perspective view of the fastener of Figure 1 illustrating the construction of the underside of the head portion,

Figure 3 is a sectional view taken along the lines 3—3 of Figure 1,

Figures 4, 5 and 6 are partial sectional views illustrating, somewhat schematically, the method or steps employed in attaching the fastener of Figure 1 to relatively thin sheet material,

Figure 7 is an elevational view, partially in section, illustrating employment of the present invention with a fastener of the internally threaded type.

Figures 8, 9 and 10 illustrate, somewhat schematically, and partially in section, the steps or method of attaching the fastener of Figure 7, and

Figure 11 is an elevational view, partially in section, illustrating another modified form of the invention.

Referring now specifically to the drawings, Figure 1 illustrates the preferred

form of the invention, engaged or mechanically interlocked with a relatively thick section of sheet material. In this regard, the self-clinching fastener is designated generally 20 while the sheet material is indicated by reference character 22. The fastener 20 includes a head section 24 and an elongated shank designated generally 26. The shank 26, in the illustrated embodiment, has a threaded end portion 28 extending axially thereof for engagement with an internally threaded member (not shown). Of course, the fastener 20 may be of the double-ended type, with a threaded portion extending from the head 24, oppositely of portion 28. In addition, said shank also includes an enlarged bulbous segment or nose portion 30 disposed intermediate said head 24 and the threaded shank 28, the portion 30 having a cylindrical surface merging into a surface convergent away from the head and reducing to the diameter of the shank 28. As will be explained more completely hereinafter, the enlarged bulbous segment 30 defines the extruding section of the shank for cold working and resizing the sheet material aperture prior to completion of the clinching operation. Formed on the intermediate portion 30 of the shank, is a circumferential locking groove 32 of relatively large width, and into which material will be forced during clinching to achieve the desired mechanical interlock.

Keeping in mind that Figure 1 illustrates the condition existing upon completion of the clinching operation, it can be seen that the fastener 20 and more appropriately the intermediate shank portion 30 is thus engaged in an aperture 34 in the sheet material 22. The aperture 34 is termed the "final aperture" for reasons which will become apparent upon completion of the description of this embodiment. In this regard, it should be noted that a small segment of the sheet material 22 has been extruded axially of the final aperture 34 to provide a rim or lip 36 about the lower periphery thereof, while an additional portion or segment of the sheet material which defines the final aperture 34 has been displaced radially inward into the locking groove 32.

The head 24 of the fastener is seated or embedded in the upper surface 35 of the sheet material 22, and as was explained above, it is this seating which completes the clinching operation and displaces material into the locking groove 32. An important feature of the present invention is the construction of the head 24. In this regard, said head 24 includes an upper cap section 40 of a generally circular configuration, and a lower section 42 of an interrupted, non-circular design. It is the lower section 42 which embeds in the upper surface of the sheet material forming still another mechanical interlock, this interlock preventing relative rotation of the fastener 20 with respect to the sheet material 22.

More specifically, the lower section 42 and head 24 is defined by a plurality of radially disposed protuberances or lobes 44, best illustrated and understood from Figures 2 and 3. The protuberances 44 are preferably disposed about the head 24 in a generally hexagonal pattern. These protuberances, as mentioned above, are firmly embedded in the sheet material, with material flowing into the intersticies 43 therebetween (see Figure 3) serving to produce a mechanical, torque-resisting interlock which prevents relative rotation.

While the protuberances 44 may be of various designs, it is preferred that they be formed to a generally arcuate configuration. That is to say, with reference to Figure 3 protuberances 44 are defined by a first series of radially outwardly curved surfaces 48, having their centers located at the corners of a regular hexagon, as indicated by dotted outline. This first series of surfaces 48 merges smoothly with a second series of inwardly, oppositely curved surfaces 50. It should be noted that the particular design or configuration of the arcuately curved surfaces illustrated is disclosed in more specific detail in British Pat. No. 1,205,445, which disclosure is incorporated herein by reference.

As can be seen further from Figures 1 and 2, each protuberance 44 extends radially outward approximately to the periphery of the cap section 40. Also, the undersurface of each protuberance 44 is defined by an inclined surface 52 angled in such a manner that the axial extent of the protuberance 44 decreases in a radially inward direction. The respective surfaces 52 co-operate to provide the head 24 with a generally frusto-conical undersurface converging in a direction toward the upper portion of said head; or to express it differently, diverging in a direction toward the extruding portion 30.

During clinching, the frusto-conical undersurfaces provided by surfaces 52 serve a significant function. More specifically, as the head 24 is driven into the sheet material, protuberances 44 will embed themselves in said material, with the frusto-conical undersurfaces provides by surfaces 52 serving to force the cold worked or displaced material radially inward toward the locking groove 32 to insure complete filling thereof. Preferably, the side walls of the locking groove 32 will be disposed at a relatively large angle to fastener axis, to resist backing out.

While Figure 1 illustrates the final

condition when the fastener 20 is clinched to a relatively thick sheet of material, Figure 6 shows the final condition which results upon employment of a generally similar fastener 20′ with a relatively thin sheet material 22′. In this regard, Figures 4 and 5 illustrate progressively the method or steps of assembly of the fastener 20′ to a thin sheet material section 22′. The steps of assembling the fastener 20 to a relatively thick sheet material 22 are essentially the same, the only primary difference being the degree of initial interference between the sheet material and the extruding portion 30, and the overall length of the extension of the rim 36 about the undersurface. Accordingly, a description will now be made of the method illustrated in Figures 4, 5 and 6, it being understood that essentially the same method will be employed with regard to assembly of the fastener 20 to achieve the conditions illustrated in Figure 1.

Turning now to Figures 4—6, the fastener 20′ illustrated is generally similar to the fastener 20 of Figure 1, except that the inclined undersurfaces 52 have not been employed. Except for this change, fastener 20′ is essentially the same and will function in approximately the same manner as fastener 20, previously described. Accordingly, the features of said fastener 20′ are designated by the same reference characters employed with regard to fastener 20 of Figures 1—3, with the inclusion of a prime (′) designation.

Looking first to Figure 4, the sheet material 22′ is provided with an initial aperture 56 sized to receive the threaded portion 28′ of fastener 20′. In addition, aperture 56 will be selected to provide a desired degree of overlap or interference with the extruding portion 30′.

The apertured sheet material 22′ is placed atop a stationary die assembly, comprised of a first, recessed die member 60, and a second die member 62 carried within said recessed member 60. It should be noted in this regard, that the illustration of the die members 60 and 62 is of a generally schematic nature.

Next after initial positioning of the fastener 20′, a ram 58 or some other appropriate type of tool is engaged against the head 24′ to move the fastener inwardly of the aperture 56 to the intermediate position illustrated in Figure 6. In moving from the condition of Figure 4 to that as illustrated in Figure 5, the extruding portion 30′ will be brought into engagement with the upper surface 35′ of the sheet material 22′ disposed about the aperture 56 and will extrude said material inwardly, as shown, to form an annular rim 36′ engaged against die members 60 and 62.

This intermediate deforming or extruding operation in effect serves to resize the initial aperture 56 to provide a final aperture 34′ of increased length having a rim 36′ disposed about the lower surface of the sheet material. As can be seen, due to the extruding operation, the wall surface of the resulting final aperture 34′ is in close sliding contact with the extruding portion 30′ of the fastener, and closely overlies the locking groove 32′. Accordingly, there is little or no play between sheet aperture 34′ and the fastener 20′ such that substantially all subsequently displaced material will flow inwardly into the locking groove 32′.

Looking to Figure 6, the clinching operation has now been completed. In this regard, in progressing from the condition of Figure 5 to that of Figure 6, the head 24′ has been seated or embedded in the upper surface 35′ of the sheet material 22′. As the protuberances or lobes 44′ are embedded in said upper surface, the material of the rim 36′ and that disposed above said rim adjacent the walls of the aperture 34′, is trapped by the extruding portion 30′ interiorly; the head 24′ and the die member 62 axially; and the die member 60 exteriorly. Accordingly, the material displaced by the protuberances 44′ as they are embedded in the sheet material has no place to flow but radially inwardly into the locking groove 32′ thus forming a tight mechanical connection. As was discussed previously, since the walls of the aperture 34′ are in close proximity to the groove 32′ substantially all of the displaced material is received into said groove so that the strength of the mechanical interlock thus obtained can be predicted and controlled in order to insure against backing out under the operating condition. It should also be remembered that the protuberances or lobes 44′ embed themselves in the sheet material with the resulting interlock preventing relative rotation between the fastener 20′ and the sheet material 22′.

Keeping in mind the above description, it can be seen that the amount of material displaced by the head 24′ can be calculated and controlled by the design of the protuberances or lobes 44′ and the cap portion 40′, if same is to be embedded in the sheet material. Preferably, assuming the hexagonal configuration provided by the lobes or protuberances 44′ and that only said lobes will be embedded in a sheet material, the volume of each lobe 44′ will be between one-fifth to one-sixth of the total volume of the groove 32′. This relationship assures displacement of a sufficient amount of material to fill groove 32′ completely, while accommodating for any compression of material or the extrusion of material past the die members. Of course, this mode of

operation or use would also apply to the fastener 20 of Figures 1—3.

If desired, the protuberances 44′ may be configured in accordance with the disclosure of Figure 1, that is provided with inclined undersurfaces 52. The operation of the fastener during the clinching step will not be changed materially, the frusto-conical undersurface thus providing further control and assurance that the displaced material moves inwardly into the groove 32′.

The above-discussed method of assembling the fastener of the present invention with a section of sheet material applies equally well to the arrangement shown in Figure 1. The only primary difference, as mentioned above, is that a lesser degree of extrusion is required wherein thick material such as sheet material 20 is encountered. With relatively thick material such as the sheet material 20 it is assured that there will be sufficient material adjacent the final aperture 34 to completely fill the locking groove 32. Thus, it is only necessary to resize the aperture slightly to assure the close overlapping contact of the aperture walls with the groove 32. Of primary significance with regard to the method of operation of Figures 4 and 5 previously discussed, is the fact that even though relatively thin material is employed, the mechanical interlock achieved is essentially the same as that obtained with the relatively thick material 22. In this regard, the axial width of the groove 32′ is approximately that of the groove 32 of fastener 20. This result, it will be recalled, is achieved by the reshaping or resizing of the initial aperture 56 to the final form, designated 34′, which aperture 34′ is partially defined by an axially extending rim 36′. What in effect has been accomplished, is a repositioning of sheet material to a location about the wall of the final aperture 34′ to assure that sufficient sheet material is available to fill the groove 32′ upon embedding of the protuberances 44′ into the upper surface of the sheet 22′. This result is achieved while also providing for the controlled, predicted interlocking engagement discussed above.

While the present invention employs the intermediate, extruding portion 30 or 30′, it should be realized that the configuration of the head 24, as shown in Figures 1—3, has great utility, when employed with more conventional clinch type fasteners. In this regard, there are two aspects of a design of the head 24 that are significant; namely, the mechanical interlock attained to prevent relative rotation, and the use of the frusto-conical undersurface to assist in forcing material inwardly into the locking groove.

Considering first the mechanical interlock provided by the protuberances or lobes 44, attention is invited to Figure 3 which is a sectional view illustrating how the sheet material is interposed in the spaces or intersticies 43 between the lobes 44. In this regard, datum circles 63 and 64 have been provided at the apexes of the lobes 44 and the inwardly curved surfaces 50, respectively. The datum circles 63 and 64, in effect, circumscribe areas of the lobes and the sheet material which are designated A and B respectively. These areas A and B are in opposed relation and it is the interengagement provided thereby which resists rotative movement of the fastener 20 relative to the sheet material 22. As mentioned previously, the general design of the lobes 44 is in accordance with the teaching of British Pat. No. 1,205,445, wherein lobes of this type are employed in conjunction with a drive system for fastener elements.

In the design of fastener elements it is often desirable to provide for control of any failures that may result during operation; in this regard, with the fastener 20 it is desired that failure occur in the screw threaded portion 28 rather than in the area of lobes or protuberances 44. The lobes 44 are therefore designed such that the sum of the areas A, as well as the sum of the areas B, are both greater than the cross-sectional area through the threaded section 28. Accordingly, if the fastener 20 is to fail under tensile loading, it will do so across said threaded portion 28 rather than in the area of the lobes 44 interlock with the sheet material 22.

Figures 7 to 11 ilustrate another modified form of the invention, which is similar to that as discussed with regard to Figures 1 to 3 and 4 to 6. In this instance, the fastener is of an internally threaded type of design to accommodate external threaded elements (not shown), and is what may be referred to as a clinched nut. The final, clinched condition for the fastener of this embodiment is illustrated in Figure 7, while Figures 8 to 10 illustrate the method of assembly. Figure 11 illustrates an alternative method of assembly wherein a boss is provided in the sheet material.

The fastener of Figure 7 is designated 110 while the sheet material to which it is connected is indicated by reference character 112; the fastener 110 being seated in a final aperture 113. In this regard, similar to fastener 20 and 20′ as discussed previously, fastener 110 is adapted for use with relatively thin sheet material, as well as with thick material, while providing a relatively wide locking groove and the improved mechanical connection occasioned thereby. In addition, as will be more apparent from the following

definition, the fastener provides for sizing of the aperture; regardless of whether relatively thick or thin material is encountered.

The fastener 110 includes a head 114 of the type as discussed previously with regard to Figures 1 to 3. That is to say, said head includes an upper cap portion 116 and a lower portion defined by a plurality of radially disposed lobes or protuberances 118, each having an inclined undersurface 120 providing the undersurface of the head 114 with a generally frusto-conical configuration. The shank 122 of the fastener 110 is considerably shorter than that of the previously discussed embodiments 20 and 20′. In this regard, the shank 122 includes a nose portion 124 that provides for the extruding operation. Disposed on the shank 122 intermediate the extruding portion 124 and the head 114 is a relatively wide locking groove 126.

As mentioned previously, the shank 122 is provided with an internally threaded portion, shown in phantom and designated 128 for reference purposes. This internally threaded portion may extend entirely through the fastener 110, or only partially into said fastener, depending of course upon the ultimate use thereof and method of assembly.

Looking now to Figures 8—10, a preferred method of assembly of the fastener 110 will now be discussed. As can be seen in Figure 8, the sheet material 112 is provided with an initial aperture 130 which is smaller than the final aperture 113 into which the fastener 110 is seated. Due to the omission of an elongate externally threaded shank, means must be provided for properly positioning the fastener during the assembly operation. In this regard, a ram 132 is provided having an elongate pin portion 134 which is receivable within the internally threaded bore 128. This pin portion 134 is of lesser diameter than the upper portion 136 of the ram, there being provided a shoulder 138 thereon.

Accordingly, the ram is brought into position with the pin portion 134 disposed interiorly of the internally threaded bore 128 of fastener 110. Due to the length of said pin portion 134, it will extend from the fastener 110 into the initial bore 130 in the sheet material 112 to position said fastener properly relative to said initial bore 130.

Once initial positioning is achieved, the shoulder 138 will be brought into engagement with the upper surface of the head 114 and the fastener is moved axially of the sheet material, which at this point rests upon a die assembly 140—142 similar to that discussed previously. In progressing from the condition illustrated in Figure 8 to that illustrated in Figure 9, the extruding portion 124 of the shank will deform the sheet material inwardly to provide a rimmed, resized aperture 146 which closely overlies the locking groove 126.

Upon movement of the ram downwardly from position illustrated in Figure 9 to that illustrated in Figure 10, the head 114 of the fastener will be embedded into the sheet material 112, with the protuberances 118 displacing material inwardly into the locking groove 126. As was discussed previously, the die members 140 and 142 serve to confine flow of the displaced material and directs that material inwardly into the groove. In addition, the lobes or protuberances 118 may be provided with inclined undersurfaces 120 which will assist in forcing the displaced material into the locking groove.

Once the fastener has been properly seated, the ram with its integral pin portion 134 is withdrawn. The final result will be the clinched arrangement as illustrated in Figure 7, with the displaced material substantially filling the locking groove 126.

With reference now to Figure 11, in using a clinch type nut it is often desirable to have the nut recessed from the undersurface of the sheet material. To provide for this, the die member 140 may be provided with an upstanding annular flange 148 while the ram (not shown) is correspondingly provided with an enlarged flange-like extension having a properly shaped surface for deforming the sheet material 112 into the configuration shown to produce the boss 150. As can be seen, by employing this arrangement the fastener will be recessed or approximately flush with the lower surface 152 of the sheet material 112. The manner of assembly in construction of the fastener 110 illustrated in Figure 11 is essentially that as discussed and described with regard to Figures 7—10 and further description thereof is deemed unnecessary.

WHAT WE CLAIM IS:—

1. A self-clinching fastener of the type for connection to a section of sheet material having an aperture formed therein, said fastener including a head and a shank, with a circumferential groove formed in said shank and said head being embeddable in said sheet material to displace material into said groove to form a mechanical interlock between said material and said fastener, said shank including an extruding segment having a nose portion converging to a reduced, non-zero diameter, in a direction away from said head and a generally cylindrical axial surface portion merging with said nose portion to provide a generally circular periphery for the extruding segment, said periphery defining the maximum diameter of said extruding

segment with said groove being disposed adjacent said cylindrical axial surface portion, the maximum diameter of said extruding segment being selected to be greater than the diameter of the aperture in the sheet material, so that upon initial engagement of the fastener with said sheet material, said extruding segment will resize said aperture with the inner peripheral wall thereof closely overlying the groove, and said head being sized such that the volume of material displaced by said head is equal to or greater than the volume of said groove, whereby, due to the peripheral wall of the aperture overlying said groove, complete filling of said groove is assured upon displacement of said sheet material by said head.

2. A self-clinching fastener as claimed in Claim 1, wherein said head includes an upper section and a lower section, said lower section including a plurality of radially disposed projections, said projections being embedded in said sheet material upon seating of said head thereby to resist relative rotation of said fastener with respect to said sheet material.

3. A self-clinching fastner as claimed in Claim 2, wherein said projections are defined by a first series of arcuately curved surfaces and a second series of surfaces curved oppositely of said first series and alternating therewith while merging smoothly with said first series.

4. A self-clinching fastener as claimed in Claim 2 or 3, wherein said projections define an undersurface for said head of a generally frusto-conical configuration, diverging outwardly in a direction away from said head, such that upon seating of said head with said sheet material, said frusto-conical undersurface will force displaced material radially inward toward said groove.

5. A self-clinching fastener as claimed in any preceding claim, wherein said extruding segment is formed unitarily with said shank.

6. A self-clinching fastener as claimed in any preceding claim, wherein said shank includes an elongate externally threaded section, of lesser diameter than said extruding segment.

7. A self-clinching fastener as claimed in any one of Claims 1 to 5, having a threaded bore extending coaxially at leat partially therethrough.

8. A self-clinching fastener substantially as hereinbefore described with reference to Figures 1 to 3, 4 to 6, 7 to 10, or 11 of the accompanying drawings.

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FIG.1

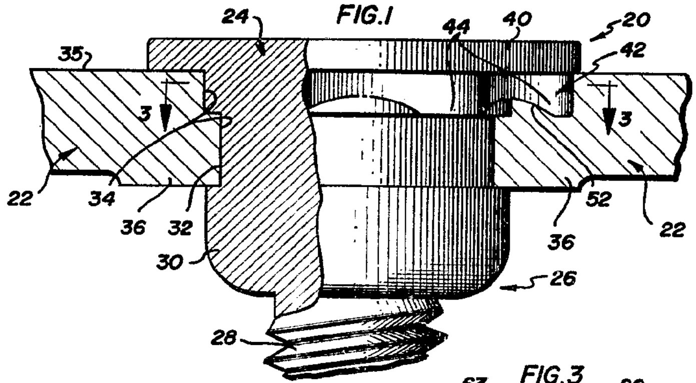


FIG.2

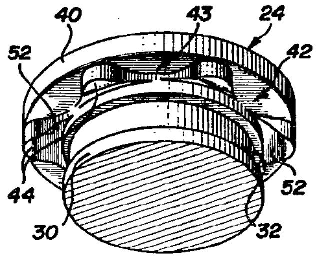


FIG.3

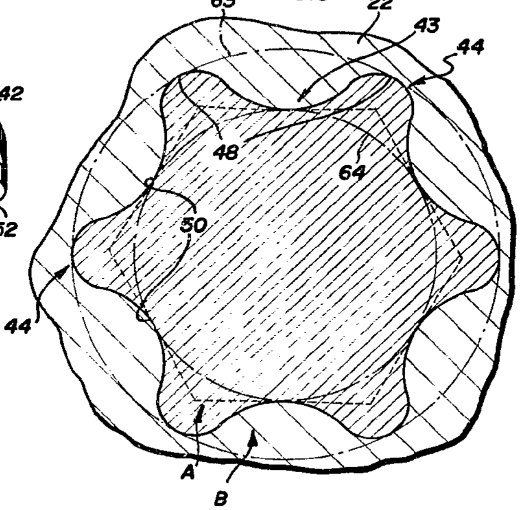


FIG. 4

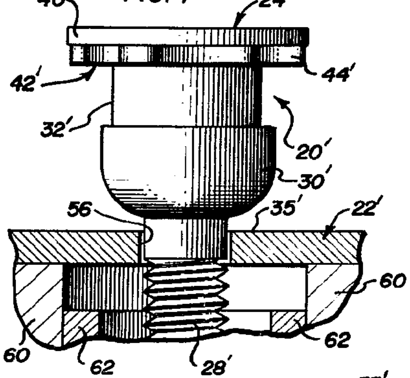


FIG. 6

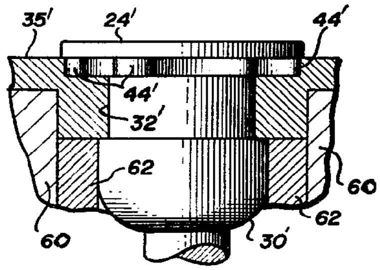


FIG. 5

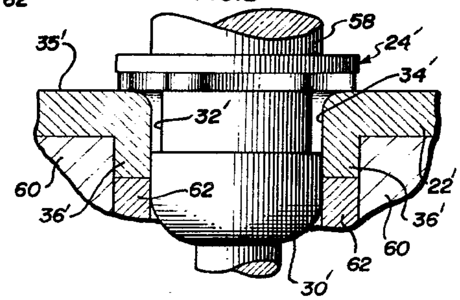


FIG.7

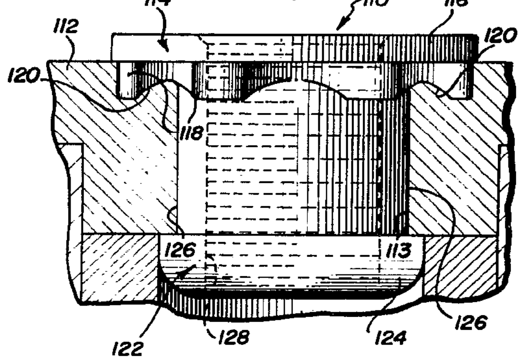
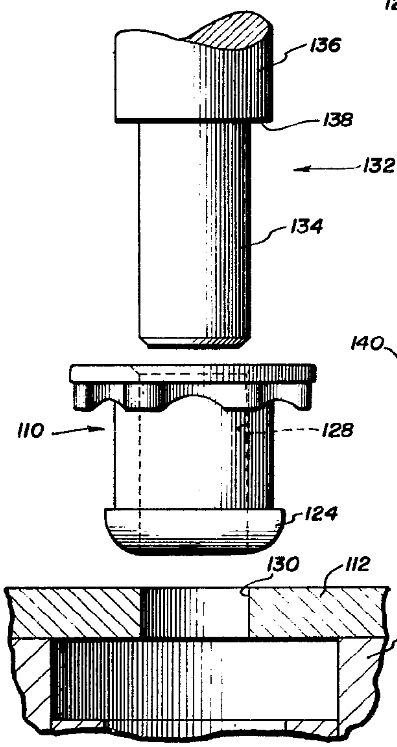


FIG.8



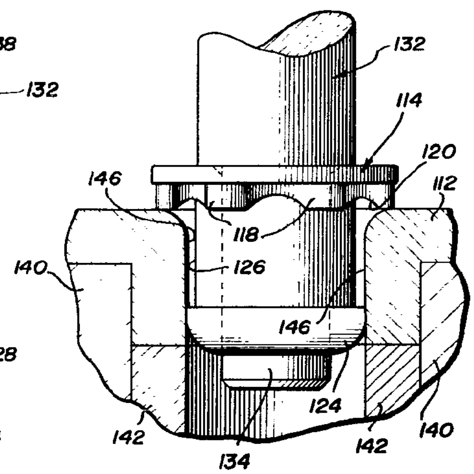
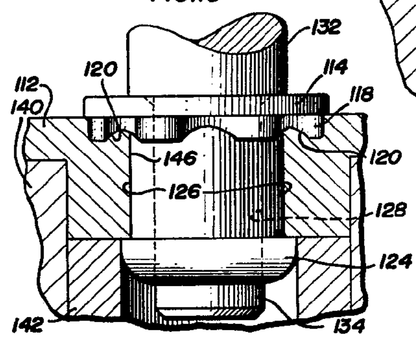


FIG.9

FIG.10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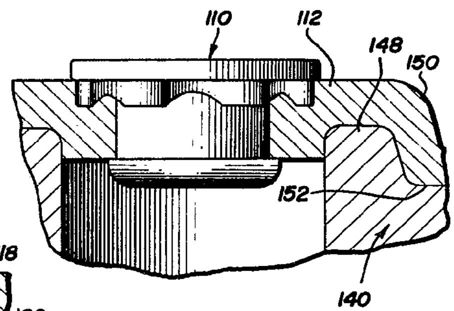
134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112
148
150
152
140

FIG.11